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ANTICIPATING THE "BLUE REVOLUTION": THE GROWTH OF THE SALMON FARMING INDUSTRY AND ITS PUBLIC POLICY IMPLICATIONS

Efforts to artificially increase salmon harvests are over a century old. The first hatchery operation began on a tributary of the Sacramento River in 1872; by the 1890s, hatcheries were commonplace in the Columbia and Puget Sound Basins. Today, the salmon runs of the Pacific Northwest are heavily dependent on hatcheries to maintain their viability. Even the Northwest Power Planning Council's Columbia Basin Fish and Wildlife Program, which favors protection and restoration of wild runs, recognizes the necessity for continued reliance on hatcheries.

Traditionally, hatcheries were "ranching" operations: that is, they released smolt to the ocean commons to grow and mature. These fish were, of course, available for harvest in the same manner as wild fish. In the 1980s, however, a new technology has emerged: salmon "farming." Instead of releasing their smolt, salmon farmers raise salmon in confined pens. In this manner they capture the entire benefit of their crop, rather than sharing it with traditional harvesters, as a ranching operation does.

Salmon farming has experienced explosive growth in recent years -- increasing over 1000% in the years 1981 to 1986, when some 70,000 tons of salmon were produced from farming operations.

Most of this production has come from Norway, the world leader, and from British Columbia, which has the fastest growing industry. And a good deal of this production is imported to the U.S. -- for example, imported Norwegian salmon increased fourfold between 1983 and 1985 and is expected to triple again by 1990. With the U.S. now importing 64% of the seafood it consumes, efforts are underway to increase U.S. production, and three states -- Alaska, Maine, and Washington -- are seriously considering the costs and benefits of allowing expanded salmon farming in their jurisdictions.

This Memo, written by Stephen White, surveys the current state of the salmon farming industry and the issues it raises in detail. Mr. White contrasts the divergent approaches to regulating the industry taken by Norway, British Columbia, and the three U.S. states. He also examines numerous environmental and socioeconomic issues that threaten the industry's growth. The Memo concludes by noting that even if the U.S. states reject expansion of farmed salmon because of genetic, water quality, or aesthetic concerns, the world trend has already been established. The "blue revolution" to which Mr. White refers -- which has seen aquaculture increase from 3% to 12% of world seafood production in the decade of 1975 to 1984 -- will almost certainly include increased reliance on salmon farming.

by Stephen M. White*

I Introduction

During the 1980's, the "salmon farming" industry has experienced remarkable growth. Since the beginning of the decade, production from salmon pen-culture has increased tenfold.¹ By 1990, it is expected to triple again, when annual world production of farmed salmon should reach an estimated 223,000 tons.²

In contrast, in recent years, the annual capture of traditionally harvested salmon³ has stabilized at about 563,000 tons. There are on-going worldwide efforts to increase this resource base. By 1990, the United States alone plans to release an estimated 2.6 billion hatchery salmon to enhance naturally spawning stocks.⁴ Nevertheless, at the end of the decade nearly 25% of the total world production of salmon could come from farms.

Not surprisingly, this rapid growth has been controversial. Salmon farming represents a new technology that threatens traditional methods, revenues, and lifestyles. Moreover, numerous questions have been raised about the environmental, social, and economic effects of raising salmon in floating pens.⁵ These questions challenge public officials who must develop policies for regulating this new industry.

This Memo examines the controversies surrounding the salmon farming industry. After a brief description of salmon farming operations, section II reviews the status of the industry in Norway, British Columbia, Washington, Maine and Alaska. These regions are at various stages in developing their salmon farming industry and each has taken a different approach to regulating the industry. Section III discusses farming's potential environmental impacts, while Section IV discusses the industry's potential socioeconomic impacts. Section V briefly outlines user conflict issues, and Section VI

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1. World farmed salmon production for 1981 was 6,880 tons. For 1986, it was approximately 70,000 tons. R. Schmitt, Director, Northwest Region, National Marine Fisheries Service, Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

2. Id.

3. In this Memo, "traditionally harvested salmon" refers to naturally spawning and hatchery stocks that are landed after spending some years maturing in the ocean commons.

4. P. Reily & J. Anderson, The Status of Atlantic Salmon Aquaculture (1986), at 2.

5. S. Nogaki, Fishing for Profits, Seattle Post-Intelligencer (Sept. 28, 1986) at C-1.

describes the different permitting approaches taken by British Columbia, Washington, Maine and Alaska. The Memo concludes, in Section VII, by offering recommendations to officials charged with regulating the industry.

II. Status of the Salmon Farming Industry

A. Current Methods of Salmon Farming

The net-pen culture of salmon is called "salmon farming" because it involves rearing salmon in floating net-pens during the entire period between their immaturity and harvest. Salmon farming should be distinguished from "salmon ranching" which involves releasing immature salmon from hatcheries into open waters and capturing them when they return to estuaries as adults. Throughout this Memo, the term "salmon farming" will refer to the net-pen culture of salmon.

Salmon farms currently raise Atlantic salmon and two species of Pacific salmon, coho (silver) and chinook (king) salmon. Atlantic salmon, which are raised throughout the world, account for 85% of the total farmed salmon production. Pacific salmon's 15% share of world production are raised primarily in Japan, British Columbia, Chile, and Washington's Puget Sound. The predominance of Atlantic salmon is largely due to the fact that Norway, the world's largest producer of farmed salmon, pioneered farming techniques with this species and raises only Atlantic salmon in its salmon farms. In addition, Atlantic salmon grow faster, have a better survival rate in net pens, and generally receive a better price in the market than do Pacific salmon.⁶

In a typical farming operation, a salmon farmer purchases year-old immature salmon, called smolts, from a hatchery where they have been raised from eggs. The farmer places the smolts in pens -- floating frames supporting large enclosures of nylon netting. During the next 18 to 24 months, the farmer feeds his stock either dry or frozen/moist feed pellets produced by commercial feed mills, wet feed from whole fish or fish wastes, or a feed that is a hybrid of these two.⁷ To prevent disease, the fish are inoculated with vaccines; if they become diseased, pharmaceuticals may be added to their feed.

At the end of this "grow out" period, the salmon have reached from 3/4 to 9 pounds, depending upon species and market requirements. They are then removed from the pens, killed, iced, and processed either at the farm or a commercial processing plant. A typical salmon farm consists of 16 pens, each 40 feet square. These pens will cover about 2.5 acres and will produce

6. S. Gilje, Salmon Farmers Turn to Atlantic, Seattle Times (Nov. 12, 1987), at E4.

7. DPA Group Inc., Industrial Organization of the B.C. Salmon Farming Aquaculture Industry (Sept. 1986), at 2-5.

about 50,000 fish each year for the market.⁸

The vast majority of farmed salmon are sold fresh to restaurants, hotels, and retail food markets.⁹ The farmer's goal, frequently achieved, is fresh delivery of his product to the wholesale consumer within 48 hours of removal from the pen.

B. Status of the Industry in Selected Regions

Salmon farming exists in 13 countries: Australia, Canada, Chile, Denmark, Finland, Iceland, Ireland, Japan, New Zealand, Norway, Sweden, the United Kingdom, and the United States.¹⁰ This Memo focuses on the status of salmon farming in 5 regions -- Norway, the Canadian Province of British Columbia, and the American states of Washington, Maine, and Alaska. Each of these regions is in a different stage of development, and each employs different approaches to salmon farming issues. Focusing on these regions illustrates the breadth of issues, divergent approaches, and various stages of development that characterize the industry.

1. Norway

Norway is the pioneer of the salmon farming industry. In 1971, its first salmon "crop" was a modest 100 tons.¹¹ By 1986, however, Norwegian production climbed to 45,494 tons, and this year it is predicted to be 75,000 tons.¹² Norway is the world's largest producer and exporter of farmed Atlantic salmon, accounting for about 80% of total world production in recent years.¹³ About 75% of Norway's farmed salmon is exported.¹⁴

Norway is also a major exporter of fish farming technology and financing. Many methods for pen-rearing salmon were perfected in Norway, and farming equipment is manufactured there for worldwide use. Although some domestic banks may be wary of investing in this new industry, Norwegian banks appear willing to finance overseas farming if the venture employs Norwegian technology.¹⁵

Despite the size of the Norwegian industry -- in June, 1987 there were 607 farms and 743 supporting hatcheries and smolt producers in the country¹⁶ -- salmon farming is largely a cottage industry. That is, most of the farms are small in scale and are run by owner-operators.¹⁷

Norwegian fish farmers enjoy a number of government subsidies, including assistance for research and development, salmon egg production, disease diagnosis services, and loan guarantees. The government has also subsidized the development of an extensive road-sea-air transportation system along the coast facilitating marketing of farmed fish.¹⁸ Finally, the Norwegian government imposes regulations to ensure quality control and sets export standards.¹⁹

2. British Columbia

British Columbia is an important salmon farming jurisdiction to consider because it has the fastest growing industry. Although farming did not get underway until the late 1970's, by 1990, British Columbia is likely to be the world's largest producer of farmed Pacific salmon,²⁰ and will be in close competition with Norway as the largest exporter of farmed salmon to the United States.²¹

Political conditions in British Columbia seem to favor the industry. With a relatively small population and 69,000 miles of mostly wilderness coastline, salmon farming conflicts with few other marine users. For example, unlike some other jurisdictions, the commercial fishing industry has not launched a strong or unified front against farmers. In fact, reportedly one of the most ambitious aquaculture groups in British Columbia is a group of commercial fishermen.²²

With nearly 12% unemployment in the province,²³ the British Columbia government appears

16. The Future of Salmon Farming in Norway, Aquaculture Digest (June 1987) at 3.

17. Gronnevet, above note 11.

18. Reilly & Anderson, above note 4, at 9.

19. National Marine Fisheries Service, The Outlook for Salmon and Shrimp Aquaculture Products in World Markets (Nov. 1984), at 48 [hereinafter NMFS Outlook].

20. V. Lipovsky, Director of Aquaculture Planning & Development, British Columbia Packers Limited, Remarks made to a University of Washington Fisheries Research Institute Seminar on Floating Marine Aquaculture, Seattle, Wa. (Jan.-Feb. 1987).

21. Rogness & Linn above note 9. Both regions are predicted to export about 20,000 tons of farmed salmon to the U.S. in 1990. Telephone communication with R. Nelles, Executive Director, British Columbia Salmon Farmer's Assoc., Vancouver, B.C. (Jan. 11, 1988).

22. R. Fitzgerald, There's No Keeping Them Down on the Farm, Alaska Fisherman's Journal (Oct. 1986), at 20.

23. Telephone communication with R. Nelles,

8. Telephone communication with Garth Hopkins, Director of Communications, British Columbia Salmon Farmers Assoc., Victoria, B.C. (Mar. 10, 1987).

9. R. Rogness & B.H. Linn, The Marketing Relationship Between Pacific and Pen-raised Salmon: A Survey of U.S. Seafood Wholesalers, Alaska Sea Grant Rep. No. 96-3 (Sept. 1986), at 1.

10. National Marine Fisheries Service, World Salmon Farming (1984), at 4.

11. L. Gronnevet, Remarks made to the Norwegian Trade Commission Fish Farming Seminar, held in Seattle, Wa. on June 5, 1986, at 2.

12. Pacific Fishing (Aug. 1987), at 15.

13. DPA Group, above note 7, at 2-2.

14. Id.

15. B. Rasmussen, Remarks before the Norwegian Trade Commission Fish Farming Seminar, above note 11.

to welcome salmon farming. No environmental impact analysis is required as part of the application process for an aquaculture site, and annual lease fees are low.²⁴ In fact, the province provides subsidies through limited interest-free loans,²⁵ veterinary services, and grants for market research.²⁶

With this sort of encouragement, the number of leased farming sites during the past 2 years increased from 10 to 125.²⁷ As of September 1987, there were 317 applications for farm leases, licenses or permits pending before the province's Ministry of Forests and Lands.²⁸ The regional salmon farmer's association predicts that by 1990 the annual production from farms will be nearly 20,000 tons.²⁹

The growth of salmon farming in British Columbia has not entirely escaped controversy, however. In October 1986, the province placed a moratorium on issuing new aquaculture leases. With over 400 lease applications on hand and with some concerns raised by a fishery and seafood processor's union, the government appointed a Commission of Inquiry to review the industry's progress³⁰ and problems and make recommendations.³⁰

After 3 weeks of meetings with the public and government officials, the Gillespie Commission published a report urging the province to continue supporting the industry.³¹ Although it offered recommendations to alleviate certain environmental, socioeconomic, and institutional problems, the commission concluded that these problems were manageable and did not warrant a continued ban on the industry's growth.³² Consequently, the moratorium was lifted, and the

government is again processing permit applications.³³ Most of the Gillespie Commission recommendations have been implemented.³⁴

3. Washington State

Given the current state of the salmon farming industry in Puget Sound, it is hard to believe that the first research began over 20 years ago.³⁵ The industry has essentially developed at a snail's pace since then.

Washington does have what is believed to be the world's largest salmon farm, the Domsea operation in Manchester. There are also 12 other commercial farms in Puget Sound, and applications are pending for 20 more.³⁶ But in the aggregate, these farms produce less than 2000 tons of salmon per year.³⁷

This slow growth is due to several factors. After investigating pen-culture, Washington researchers diverted their attention to other types of aquaculture, notably shellfish and salmon ranching,³⁸ probably because at the time these techniques showed promise of being more economically feasible.³⁹ Other factors hindering industry growth were the lack of fish vaccines in the early 1970's, and poor siting decisions by some farmers in Puget Sound.⁴⁰ Later, when the Puget Sound industry tried to expand, it was hampered by fragmented government policies and public opposition, mainly from upland bordering Puget Sound has authority to establish its own criteria for issuing aquaculture permits.⁴¹ Currently, 3 counties have imposed moratoria on issuing permits for salmon farms.⁴²

above note 21.

24. C. Miller, Salmon Farming Goes Crazy in B.C., Alaska Fisherman's Journal (Feb. 1987), at 32.

25. Lipovsky, above note 20.

26. DPA Group, above note 7, at iv, v.

27. M. Coon, British Columbia Ministry of Agriculture & Fisheries, Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

28. Telephone communication with T. Cockburn, British Columbia Ministry of Forests and Lands, Victoria, B.C. (Jan. 14, 1988).

29. Telephone communication with Nelles, above note 21.

30. The commission was chaired by David Gillespie, an attorney ("solicitor") from Kamloops, B.C. Mr. Gillespie was selected by the British Columbia government because he was perceived to be fair, thorough, and had no previous knowledge or contact with aquaculture issues. The inquiry is often identified with his name. Telephone communication with T. Cockburn, British Columbia Ministry of Forests and Lands, Victoria, B.C. (Feb. 5, 1988).

31. British Columbia Finfish Aquaculture Inquiry, An Inquiry into Finfish Aquaculture in British Columbia, Report and Recommendations (Dec. 1986) [hereinafter Gillespie Report].

32. Id. at 31.

33. Telephone communication with Nelles, above note 21.

34. Coon, above note 27. See below text accompanying notes 120-22.

35. J. Forster, General Manager, Sea Farm Washington, of Norway, Remarks made to a Fisheries Research Institute Seminar, above note 20.

36. Telephone communication with Bob Hoyer, Aquatic Lands Division, Washington Department of Natural Resources, Olympia, Wa. (Jan. 14, 1988).

37. Forster, above note 35. The 1986 production of farmed salmon in Washington was 1477 tons. Telephone communication with John Pitts, Aquaculture Coordinator, Washington Dep't of Agriculture, Olympia, Wa. (Jan. 12, 1988).

38. Id.

39. Telephone communication with J. Forster, General Manager, Sea Farm Washington, of Norway, Port Angeles, Wa. (Feb. 3, 1988).

40. Personal communication with Jack Rensel, Milner-Rensel Assoc., Seattle, Wa. (May 5, 1987).

41. B. Saunders, Washington Dep't of Ecology, Remarks made to a Fisheries Research Institute Seminar, above note 20.

42. These counties are Jefferson, San Juan Island, and Skagit. Telephone communication with John Pitts, above note 37. The counties' moratoria may conflict with the state's shoreline management program and thus be unconstitu-

The reluctance of local governments to endorse salmon farming is largely due to the outspoken concern of their constituents on 2 issues: (1) public concern over the industry's perceived threat to Puget Sound water quality; and (2) concern of upland owners about the visual impact of floating pens. Upland owners fear that salmon farms will have a negative impact on their aesthetics, property values, and recreational use of the coastline.

Nevertheless, in 1985 the Washington State Legislature passed a bill encouraging the promotion of aquaculture.⁴³ The next year, the government commissioned an analysis of the industry's environmental impacts and its alleged conflicts with other marine users. Early in 1987, it issued recommended interim guidelines intended to promote proper pen siting and operation.⁴⁴ The state is now encouraging local governments to adopt these standards in order to create more uniformity within the state.⁴⁵ Toward the same end, the Washington Legislature recently approved funding of a programmatic study of all of the industry's impacts,⁴⁶ and the governor announced a state policy promoting development of the aquaculture industry, provided environmental safeguards are maintained.⁴⁷

4. Maine

In Maine, the salmon farming industry is in a beginning stage, but has grown rapidly during the past year. By the end of 1986, the Maine Department of Marine Resources had issued leases for 6 salmon farms, but only one of these was in actual operation. Since then, the Department has issued 11 more leases. Most of these lease sites are operational, although some farmers have had to begin raising trout due to the present lack of salmon smolt.⁴⁸

Before last year, Maine had taken a relatively permissive approach toward the new industry. The only criteria for issuing a lease application was that the potential farm could not interfere with other users, particularly upland owners and lobster fishermen.⁴⁹

tional. Letter from A. Miller, Assistant Attorney General, State of Washington to Doug Sayan, Washington State Representative (Dec. 4, 1987).

43. S.B. 3067, 48th Leg., 1985 Reg. Sess., codified at Wash. Rev. Code § 15.85.010-060.

44. Washington Dep't of Ecology, Recommended Interim Guidelines for the Management of Salmon Net-Pen Culture in Puget Sound (Dec. 30, 1986).

45. Saunders, above note 41.

46. H.B. 3370, § 310, 50th Leg., 1987 Reg. Sess.

47. B. Gardner, Governor, State of Washington, Press Release (Sept. 28, 1987) and Remarks made to Governors Conference on Aquaculture, Tumwater, Wa. (Jan. 30, 1988).

48. Telephone communication with Ken Honey, Hearings Officer, Maine Dep't of Marine Resources, Augusta, Me. (Jan. 14, 1988).

49. Telephone communication with Peggy McCloskey, Assistant Attorney General, State of

In 1987, however, the Maine Legislature reduced the number of aquaculture leases, established application and rental fees, and added environmental, user conflict, and other criteria to the application procedure.⁵⁰ Among other requirements, potential farmers must now identify their source of salmon smolt and characterize their farm's possible impact on existing uses and on the marine environment.⁵¹ State officials expect that these restrictions will slow down the industry's growth in Maine.⁵²

5. Alaska

With thousands of miles of uninhabited and unpolluted coastal waters, along with an established infrastructure for processing and marketing salmon, Alaska has the potential to become a major salmon farming region. However, salmon farming in Alaska is in an ambiguous legal position, and the only operating facilities are a government research facility and a private, freshwater tank farm.⁵³ Until recently, development of net-pen aquaculture was hampered by several Attorney General opinions concluding that certain activities critical to the industry were not authorized by state law or regulation.⁵⁴

In early 1987, legislation to clearly authorize regulation of salmon farming was introduced in the state legislature.⁵⁵ The principal opposition to this legislation came from commercial fishing groups fearing that new sources of farmed salmon would create greater competition for their "harvested" fish. These groups also argued that a farming industry would be dominated by multinational corporations and foreign investment, thus having a negative impact on local economics in rural Alaska.⁵⁶

Maine, Augusta, Me. (Jan. 29, 1988).

50. Me. Rev. Stat. Ann. tit. 12, § 6072.

51. Id. § 6072(4).

52. Telephone communication with Honey, above note 48.

53. The tank farm facility is permitted under ch. 7, 1987 Alaska Sess. Laws, which allows farms that operate only in a contained area. Telephone communication with A. Wescott, owner at Mrs. Andy's Coho Farms, Fairbanks, Ak. (Feb. 3, 1988).

54. Memorandum from L. Spengler, Assistant Attorney General, to Don Collinsworth, Commissioner, Alaska Dep't of Fish and Game, Dep't of Law File No. 366-187-84 (Jan. 31, 1985). In particular, the Attorney General stated that under existing regulations, salmon farms did not qualify for a permit which would allow them to hold live fish. 1985 Inf. Op. Attorney General (Jan. 31; 366-187-84), 1987 Inf. Op. Attorney General (Mar. 10; 661-87-0306), 1987 Int. Op. Attorney General July 8; 663-87-0454). Telephone communication with L. Spengler, Assistant Attorney General, Alaska Dep't of Law, Juneau, Ak. (Feb. 3, 1988).

55. S.B. 106, H.B. 108, 15th Leg., 1st Sess. (1987).

56. See M. George, Fish Farming Sprouts Controversy, Southeastern Log (Jan. 1987) at 15.

In May 1987, the Alaska Legislature passed a bill placing a moratorium through July 1988 on issuing permits for salmon farming in open waters.⁵⁷ Nevertheless, the state Department of Commerce and Economic Development is continuing to investigate the potential impacts of the industry. It has contracted to develop a cost production model for a typical Alaska salmon farm and to analyze market demand for fresh/frozen salmon.⁵⁸

As each region further develops its salmon farming industry, policy makers must deal with the industry's projected socioeconomic impact and numerous potential adverse effects on the environment. The next section surveys some of the principle environmental issues that must be confronted.

III. Environmental Issues

The environmental impact of salmon farming is perhaps the most controversial issue facing the industry today. The issue is pressed by groups worried about potential adverse effects on the marine environment and also by those whose concerns are grounded on protecting their economic or aesthetic interests. Often it is difficult to distinguish one from the other. The environmental issue is further complicated by the fact that it has been raised relatively late in the industry's development.

The environmental issue is now being intensively studied throughout the world, most notably in Sweden, Norway, Scotland, and Finland. According to one industry analyst, British Columbia is the only major farming region where environmental studies are disproportionately low compared to the intensity of farming.⁵⁹

Washington is in the forefront of this inquiry, where the issue is being pressed by a consortium of 9 citizen groups, as well as a number of national environmental associations.⁶⁰ In 1986, the state commissioned a synopsis of existing research on this issue. The researcher, Dr. Donald Weston,⁶¹ reviewed international

literature, but he neither gathered nor analyzed additional data. Nevertheless, his report, The Environmental Effects of Floating Mariculture in Puget Sound⁶² is the most detailed and significant analysis of this subject.⁶³

A. The Environmental Impacts of Salmon Farming

Dr. Weston rated 10 environmental impacts according to how completely their effects have been documented. The following discussion of those impacts begins with those which have well-documented effects and which are, according to Weston, more predictable.⁶⁴ The discussion proceeds to consider impacts which have lesser known effects, and thus are more speculative. Following these 10 impacts are 3 additional impacts not discussed in the Weston report but which have been topics of public concern.

1. Water Circulation and Suspended Sedimentation

Net-pens alter flow patterns and impede the velocity of surrounding water current. Since the ability of water to transport sediments is directly related to its velocity, the pens may increase the deposition of suspended sediments. Water circulation is also impeded within the pens which may inhibit both the entry of oxygenated water and the removal of metabolic wastes from the pens.

The exact effect on water flow will vary depending upon facility design and operation factors that can be controlled by individual farmers. These factors include the size of the net mesh, how fouled the netting is with marine growth, how densely loaded the pens are with fish, and how the pens are aligned relative to the current flow.

Weston predicted that if pens are widely distributed across an area which has good water flow, the impact on circulation will be insignificant. Likewise, if the pens are located in deep enough water, he felt that the deposition of suspended sediments will be insignificant in waters like Puget Sound which have relatively

57. S.B. 297, 15th Leg. 1st Sess. (1987), Ch. 70, 1987 Alaska Sess. Laws. With the expiration of the one year moratorium approaching, the Alaska Legislature is currently considering several salmon farming bills, ranging from a complete moratorium on farming to clearly authorizing limited farming.

58. Alaska Mariculture Assoc., 2 Alaska Mariculture Report no. 2-3 (Dec. 1987-Jan. 1988) at 12.

59. Letter from Donald Weston to the author (Apr. 13, 1987).

60. Probably the most vocal citizen group in Puget Sound is the Griffin Bay Preservation Committee. National associations which have become involved in this issue include the Audubon Society, Greenpeace, and the Sierra Club. J. Brookbank, Remarks made to a Fisheries Research Institute Seminar, above note 20.

61. Ph.D. Marine Science; Post-doctoral Research Associate, Puget Sound Institute, Univer-

sity of Washington, Seattle, Wa.; U.S. delegate to the Study Group on the Environmental Impact of Mariculture, sponsored under the auspices of the International Council for the Exploration of the Sea.

62. D. Weston, The Environmental Effects of Floating Mariculture in Puget Sound (1986) [hereinafter Weston Report].

63. Personal communications with John Pitts, Washington Dep't of Agriculture, Olympia, Wa. (Nov. 10, 1986) and Eric Hurlburt, Washington Dep't of Fisheries, Olympia, Wa. (Nov. 10, 1986); Telephone communications with Ed Black, British Columbia Ministry of the Environment, Victoria, B.C. (Nov. 25, 1986) and Conrad Mahnken, National Marine Fisheries Service, Manchester, Wa. (Dec. 1, 1986).

64. D. Weston, Remarks made to a Fisheries Research Institute Seminar, above note 20.

low suspended sediment loads.⁶⁵

2. Organic Sedimentation and Impacts on Benthic Organisms

Salmon farming is a source of organic sediments which have an adverse effect on benthic organisms when they settle. These organisms include small worms, mollusks, and crustaceans that burrow or have intimate contact with the ocean bottom and are consumed by bottom feeding fish. The accumulation of organic sediment beneath the net-pens is due usually to excess fish feed and to feces. For example, an estimated 5% of the feed used in Puget Sound is not consumed.⁶⁶ When this matter is added to feces, Weston calculated that .7 tons of organic solid waste is generated for each ton of fish produced.⁶⁷

In shallow or poorly flushed pen sites, this waste material may settle in a soft, flocculent layer beneath the pens. The accumulation will cause changes in the ocean bottom chemistry typical of high organic loading, including increased oxygen consumption, organic enrichment from nitrogenous compounds and phosphates, and increased concentrations of sulfides. Chemical changes extend about the same distance out from the pens as do the accumulated sediments -- typically not more than 30 meters. This is the area where benthic organisms living on or beneath this layer would be adversely affected.⁶⁸

The response of benthic organisms follows predictable patterns. At lower levels of organic enrichment, their numbers may actually increase. At mid-levels, the number of species declines, but the abundance of hardy, opportunistic members, such as polychaetes, increases. At higher levels, when the bottom sediment and overlying water becomes totally anaerobic, all members of this community will disappear.

This continuum of change from a healthy, diverse community to total mortality of the benthic organisms may occur spatially as a function of distance from the pen site. It may also occur temporally as a function of the accumulation of organic sediment over time. After sedimentation ceases, it may take from 2 to 10 years for the benthic population to recover.⁶⁹

Weston observed that accumulation of organic sediment and consequent changes in bottom chemistry causing benthic mortalities depend on the degree to which organic wastes are dispersed by water movement. As current or water depth beneath the pens increases, potential adverse effects on benthos decreases.⁷⁰

3. Fish and Megafauna Impacts

Salmon farms will likely adversely effect larger, nonmobile animals living on the ocean bottom or burrowing in it. These animals, typically clams and other bivalves, are vulnerable to the same anoxic conditions created by the decomposition of organic sediments.

On the other hand, crabs, starfish, finfish and other mobile species may actually prosper in the vicinity of most net-pens. Weston cited anecdotal evidence suggesting that (1) mobile communities increase in abundance and diversity, and (2) opportunities for recreational fishing are enhanced by the presence of net-pens. He attributed these suggestions to the tendency of some species of fish to congregate around floating objects and to the increased availability of food near the pens.⁷¹

4. Water Quality Impacts

Net-pen culture adds ammonia, phosphate, nitrate, and nitrite while removing dissolved oxygen from the surrounding water, primarily as a result of fish waste products. Oxygen is removed by the respiration of the fish and by decomposition of their feces and excess feed.⁷²

Weston believed that the most significant of these impacts, the increase in ammonia and decrease in oxygen, should not be a problem for moderate-sized farms in Puget Sound that are dispersed and sited in locations having adequate water circulation. He cautioned, however, that too much production in a small area or pen sitting in areas of poor flushing may lead to problems in the form of increased ammonia or decreased oxygen.⁷³

Although increases between 25% and 500% have been observed in ammonia concentration in net-pens, Weston pointed out that these increases are well below toxic levels.⁷⁴ And while dissolved oxygen has been reported to decrease between 2% and 30% in the pens, he concluded that, after water has passed through the pens, dispersion and dilution with surrounding waters will rapidly return it to normal oxygen levels.⁷⁵

Weston felt that the absence of conclusive research made predictions about the waste loading and oxygen depletion caused by any particular facility difficult. He equated the impact of a large farm (say, 50 net pens) to that of a small river or dairy, but cautioned against comparing farms to sewage generated by human populations. Although loading levels of a 50-pen farm are equivalent to the untreated sewage discharge of 10,000 humans, Weston maintained that the former contains neither the high levels of toxins nor the pathogenic organisms of the lat-

65. Weston Report, above note 62, at 20-21.

66. This figure is based upon non-quantitative estimates by farmers. Attempts in Europe to quantify feed loss have reported values between 1% and 30%. Letter from Weston, above note 59.

67. Weston Report, above note 62, at 49.

68. Id. at 62.

69. Id. at 72.

70. Id.

71. Id. at 76.

72. Id. at 22-23.

73. Letter from Weston, above note 59.

74. Weston Report, above note 62, at 36.

75. Id. at 37.

ter. Human waste enters as fresh water and disperses less readily with surrounding seawater. Since aquaculture uses much more water per unit of product than do other processes, its by-products become highly diluted rapidly.

According to Weston, concern that water quality would be threatened beyond the immediate vicinity of net-pens is unwarranted in most salmon farming areas. Aquaculture studies in Washington and British Columbia showed little or no observable effect on water quality outside of the pens.⁷⁶ Adverse effects would be likely only where pens are located in areas of very limited water flushing, or where pens are highly concentrated in a limited area.⁷⁷ Proponents point out that the U.S. Environmental Protection Agency draws its regional water quality sample from a site not more than 300 meters from the world's largest salmon farm in Washington and directly next to a federal net pen research complex. This water is used as a clean water standard against which samples of suspected polluted water are compared.⁷⁸

5. Increased Phytoplankton Growth

Phytoplankton, the microscopic organisms at the bottom of the marine food chain, require nitrogen, phosphorous, and other nutrients and elements to sustain growth and reproduction. Thus, there is some concern that the addition of these nutrients by salmon farms may stimulate rapid phytoplankton production. These "blooms" could cause fish mortality and may even threaten human health if they contain organisms responsible for paralytic shellfish poisoning.

Although correlations between aquaculture and increased plankton blooms have been reported in Japan,⁷⁹ no clear cause and effect relationship has been established either there or in Puget Sound. While nitrogen availability is the limiting factor for plankton production in most marine environments, Weston noted that most of Puget Sound contains more nitrogen than can be used by the plankton. In those waters, growth-limiting factors are primarily low light and vertical mixing that produces unstable water columns.⁸⁰ Thus, even if all nitrogen available under specified conditions were consumed by a farm in Puget Sound, plankton growth would be undetectable. Under more normal conditions -- that is, high mixing and nutrient dilution -- a bloom would be even less likely.⁸¹

Weston cautioned, however, that a localized, measurable increase in plankton could occur in an area with poor flushing and a highly stratified water column, where a parcel of water could retain its integrity over a long period of time or be repeatedly cycled through the pens. Ab-

sent these conditions, though, he believed that salmon farms are unlikely to have measurable effects on plankton growth.⁸²

6. Introduction of Non-native Species

Exotic marine life, introduced intentionally or by accident, can carry new diseases or parasites, compete with native species for nutrients or habitat, or develop into uncontrolled pests. In British Columbia, concern over native species focuses on the importation of infected salmon eggs. The fear is that imported Atlantic eggs may introduce exotic diseases for which Pacific salmon have no immunity.⁸³ A similar fear has been expressed in Alaska.⁸⁴

Weston reviewed the history of introducing non-native species, concluding that this practice probably represents aquaculture's greatest threat to the environment.⁸⁵ But he alleged that the risk today is less than it was in the past, due to increased awareness of the problem and to the adoption of strict governmental controls on the import and transport of non-native plants and animals.

The risk created by the salmon farming industry may be particularly remote in Puget Sound if the farms' only non-indigenous salmonid species remains Atlantic salmon farmed in Puget Sound. Reportedly, Atlantic salmon escaping the pens do not create a competing stock, but instead tend to congregate around their pens or are eaten by predators.⁸⁶

There have been numerous attempts to create an Atlantic salmon run in the Pacific Northwest; according to one estimate, about 5 million Atlantic salmon have been intentionally released in Northwest waters.⁸⁷ For 30 years, the government of British Columbia has attempted to establish a wild stock of Atlantic salmon in British Columbia.⁸⁸ None of these attempts, however, has succeeded. Apparently, unpenned Atlantic salmon are unable to sustain a viable population in the Pacific Northwest. Researchers believe that the Atlantics do not compete well with more aggressive Pacific species in the same waters.⁸⁹

7. Use of Antibiotics and Hormones

Salmon farmers use food additives for various purposes. Hormones may be added in order to manipulate the sex of salmon used for brood

76. Id. at 38.

77. Id. at viii.

78. Alaska Mariculture Assoc., 1 Alaska Mariculture Report no. 9 (July 1987) at 4.

79. Id. at 40-41.

80. Id. at 42.

81. Id. at 46.

82. Id.

83. See Gillespie Report, above note 31, at 15.

84. See George, above note 56.

85. Weston Report, above note 62, at 82.

86. Gillespie Report, above note 31, at 16.

87. Weston Report, above note 62, at 80 (citing an unpublished report by J. Lindbergh).

88. P. Moore, Remarks made to a Fisheries Research Institute Seminar, above note 20.

89. Telephone communication with J. Lindbergh, aquaculture consultant, North Bend, Wa. (Feb. 3, 1988).

stock.⁹⁰ Antibiotics may be employed to stop the spread of disease.

According to salmon farmers in British Columbia, there is no scientific evidence that these hormones are harmful to humans eating the fish. They contend that farmed fish actually have fewer hormones when marketed than do traditionally harvested salmon.⁹¹ In any event, the hormone issue has not created much controversy.

The same cannot be said about the use of antibiotics. One critic of the industry, Dr. John Brookbank, a cellular biologist, claims that antibiotic usage in Norway has increased to the point where about 147 pounds of tetracycline are used annually for every acre of salmon pens.⁹² He fears that these substances will work their way into the food chain through the ingestion of excess feed by bottom dwellers. An even greater concern is that this usage will retard the growth of bacteria beneficial to the marine environment or foster development of strains resistant to antibiotics and harmful to humans.

On the other hand, proponents of the industry claim that the use of antibiotics is very limited and is decreasing. According to one, only 2.4% of the fish sold in Puget Sound during 1987 was treated with antibiotics.⁹³ Dr. John Pitts, a veterinarian and Aquaculture Coordinator for the Washington Department of Agriculture, claims that the use of antibiotics by European farmers has decreased dramatically.⁹⁴ He attributes this reduction to farmers using better husbandry practices and becoming better educated on how to use the pharmaceuticals. With the forthcoming development of fish vaccines, Pitts expects that antibiotic use will decline further.⁹⁵

Weston identified 3 antibiotics currently licensed by the federal Food and Drug Administration for use in salmon farms: oxytetracycline (OTC), sulfamazine, and Romet 30. Since OTC is the most widely used antibiotic in Puget Sound, he limited his examination to this drug, acknowledging that there is little data with which to evaluate the environmental consequences of OTC use.⁹⁶ Nevertheless, there are

several mitigating factors which should be considered.

First, the antibiotic is limited to therapeutic uses. In contrast to the livestock industry, which applies antibiotics continuously to prevent disease and improve growth rate, fish farmers use OTC only to treat disease outbreaks -- typically only 20-30 days each year. Second, OTC use is inhibited by the high cost of the drug and by the fact that it tends to reduce fish growth rate.⁹⁷ Third, the U.S. Food and Drug Administration prohibits the sale of any fish with a detectable concentration of any antibiotic in its tissue, imposing a 21-day waiting period between OTC usage and harvesting. Fourth, OTC is readily soluble in seawater and dilutes rapidly in moving water. Since it appears to be relatively non-persistent, it is unlikely that OTC would have more than a short-term effect on the marine community surrounding a salmon net-pen.⁹⁸ These factors led Weston to the tentative conclusion that the present pattern of antibiotic usage should not be a major environmental concern.⁹⁹

8. Proliferation of Human Pathogens

Salmon farming might lead to increased numbers of bacteria harmful to humans. This public health concern has focused on the bacteria genus Vibrio which thrives on the feed and feces around net pens. Several species of this bacteria are common in marine waters and marine organisms; it is particularly abundant in areas of high organic concentrations. Harmful species of Vibrio can be concentrated by shellfish and, when consumed by humans, have the potential of causing illness or even death.¹⁰⁰

In spite of the abundance of this bacteria, Weston observed that the incidence of Vibrio infection has been relatively low. He attributed this to several factors. Most Vibrio strains are incapable of causing infection in humans, and the cool temperatures of Puget Sound prevent pathogenic species from reaching harmful proportions. Moreover, risk of infection can be minimized by avoiding uncooked shellfish and by not siting pens over harvestable shellfish beds.¹⁰¹

The scientific evidence on this issue is sparse and merits further research. Because there is no evidence of human health problems despite years of nearby aquaculture, Weston believed the health risks to be very low, an insufficient reason for curtailing the industry. He concluded, "at most, perhaps there should be a small buffer zone around net pens ... but even the need for this has not been demonstrated."¹⁰²

90. DPA Group, above note 7, at 19.

91. *Id.*

92. J. Brookbank, Aquaculture, Effects on Marine Environment (Sept. 1986), at 1.

93. A. Bill, President, San Juan Island Aquaculture Assoc., Remarks made to Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

94. In 1985, Finland used between 1% and 3% of the antibiotics used in 1982. Telephone communication from John Pitts, Aquaculture Coordinator, Washington Dep't of Agriculture, Olympia, Wa. (Feb. 18, 1988) (relaying information from Dr. Goran Bylund, Swedish University, Torku, Finland).

95. J. Pitts, Aquaculture Coordinator, Washington Dep't of Agriculture, Remarks made to a Fisheries Research Institute Seminar, above note 20.

96. Weston Report, above note 62, at 96.

97. Communication with Rensel, above note 40.

98. Weston Report, above note 62, at 98.

99. *Id.* at 100.

100. Brookbank, above note 92, at 1.

101. Weston Report, above note 62, at 88-89.

102. Letter from Weston, above note 59.

9. Transmission of Disease to Wild Fish

Penned salmon experience more stress than wild salmon; therefore, they are more susceptible to disease. This susceptibility prompts concern that salmon farms will provide fertile grounds for disease to multiply, become more virulent, and infect wild stocks.

According to Weston, however, this scenario has never been documented. Most disease pathogens are always present in the marine environment but only cause disease in those fish that are stressed by malnourishment, overcrowding, or physical injury. Weston concluded that there is a very low probability that these diseases would be transmitted from penned fish to healthy, unstressed wild fish.¹⁰³ Although researchers agree that disease transmission is possible, they say that detecting and tracing a disease to its source would be difficult.¹⁰⁴ Even opponents of salmon farming concede that there have been no reports of epidemics being caused by aquaculture operations.¹⁰⁵ In fact, all reports of infestation have involved wild stocks transmitting disease to farmed fish, not vice versa.¹⁰⁶

10. Genetic Alteration

Farmed fish may escape and interbreed with indigenous species. There are a number of reasons to minimize opportunities for interbreeding. Cultured genetic strains have been bred for captivity and thus are less adapted for life in the wild. Also, some strains may have reduced genetic variability that limits their ability to cope with environmental change.¹⁰⁷

Environmental groups have voiced particular concern over the genetics issue. They report that the Norwegians are creating a gene bank to safeguard the purity of indigenous Atlantic salmon stocks.¹⁰⁸ The Norwegians apparently believe that the native species is being threatened by salmon farming, as well as by forestry practices, acid rain, and hydroelectric development.¹⁰⁹

Weston claimed that the lack of reliable data makes this risk speculative, pointing to a

couple of factors that should limit concern about genetic alteration. First, hatcheries have been introducing millions of Pacific salmon into Puget Sound for some 75 years. The potential release from net-pens would be insignificant in comparison; genetic damage, if any, has probably already occurred.¹¹⁰ But so far, studies have failed to identify any such damage.¹¹¹ Second, all attempts to cross breed non-indigenous Atlantic salmon (which belong to a different genus than the native Pacific salmon) have been unsuccessful. In the event of escape from pens, Weston concluded that the greatest effect, if any, may be a temporary loss of some reproductive capacity in the wild population.¹¹²

11. Use of Toxic Substances

Substances used by the salmon farming industry may create health hazards. Concern has focused on the chemical tributyltin (TBT), a tin-based toxicant that prevents the growth of marine organisms. TBT is used in some vessel bottom paints and by salmon farmers to prevent the fouling of net-pens. Although TBT reportedly accumulates in the flesh of farmed salmon and shellfish, to date there has been no showing that this chemical is a risk to human health.¹¹³

Nevertheless, government agencies and the industry are beginning to restrict use of this toxicant. The British Columbia Salmon Farmers Association discourages its members from using TBT.¹¹⁴ In Alaska, the National Marine Fisheries Service has decided to eliminate the use of TBT in all of its hatcheries and fish culture projects.¹¹⁵ In Washington, farmers have pledged to not use this anti-foulant.¹¹⁶

12. Conflicts with Marine Birds and Mammals

Marine animals may be attracted to salmon farms in order to prey on penned fish. Birds, land otters, seals, and sea lions reportedly can become persistent in trying to break into the enclosures. The severity of this problem seems to differ from region to region. In British Columbia, farmers claim that predators account for less than 1% of all losses.¹¹⁷ At a research project in Alaska, however, harassment and attacks by predators "continue to be one of the major factors causing significant losses of fish in seapens."¹¹⁸

103. Id.

104. Communication with R. Elston, M. Kent, Research Scientists, Battelle Pacific N.W. Laboratories, Tumwater, Wa. (Jan. 30, 1988).

105. J. Brookbank, President, Marine Environmental Consortium, material presented at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

106. Id. See also Weston Report, above note 62, at 89.

107. Weston Report, above note 62, at 92.

108. Telephone communications with Athena McIntyre, Preserve Our Water, Environment & Resources (Dec. 1, 1986); Vivian Boe, Greenpeace (Dec. 2, 1986).

109. Telephone communication with John Pitts, Aquaculture Coordinator, Washington Dep't of Agriculture, Olympia, Wa. (May 14, 1987).

110. Letter from Weston, above note 59.

111. Communication with Rensel, above note 40.

112. Weston Report, above note 62, at 95.

113. Letter from Weston, above note 59.

114. Moore Remarks, above note 88.

115. Alaska Mariculture Association, 1 Alaska Mariculture Report no. 3 (Jan. 1987), at 5.

116. Communication with Rensel, above note 40.

117. Moore Remarks, above note 88.

118. W. Heard, Salmon Farming Research in Alaska, 1 Alaska Mariculture Report no. 3 (Jan. 1987), at 5.

Methods to discourage these animals include barriers, electric shock, and gunfire. Since there may be injury and death, bird and mammal control techniques have met strong public opposition. According to a spokeswoman for the National Audubon Society, resolving the industry's conflict with marine wildlife is one of that group's highest priorities.¹¹⁹

13. Impacts from Associated Hatchery and Processing Operations

If salmon farming operations are vertically integrated, the hatchery and processing components will produce separate, additional environmental impacts. Adverse effects include generation of waste water containing high concentrations of metabolites. There may also be an accumulation of fish blood and offal from processing.

Policy makers cannot ignore these impacts. Information about their dimension and management can be readily obtained from recognized sources on salmon hatcheries and processing. But since these operations are governed by current state and federal regulations, an in-depth examination of these impacts is beyond the scope of this Memo.

B. Policies for Managing Environmental Impacts

1. Need for Further Research

Before certain questions can be answered conclusively, most analysts agree that further research is needed. In British Columbia, the Gillespie Commission called for government supported research on water quality, shellfish, and other bottom dwellers affected by the industry. The commission recommended that this support come in the form of government grants to private researchers and universities as well as investigations by government staff.¹²⁰ The commission also recommended increasing government research, inspection, and testing activities regarding the effect of toxicants, hormones, and antibiotics, and creating a regional aquaculture research center to coordinate these services and studies.¹²¹

The Gillespie Commission also suggested a mandatory system of environmental monitoring and data collection at each farm site, with the government establishing the parameters to be measured, setting standards, and prescribing methods of measuring, recording, and reporting. The results of such a system would assist the studies of long-term environmental change and also help officials determine whether a particular operation should be closed down or moved because of adverse environmental effects.¹²²

119. P. Crocker-Davis, Remarks made to a Fisheries Research Institute Seminar, above note 20.

120. Gillespie Report, above note 31, at 36.

121. Id. at 39.

122. Id.

Due to the efforts of Washington, much of this research will be forthcoming. The 1987 legislature approved funding for the preparation of a programmatic environmental impact statement on the impact of salmon farms in Puget Sound. The EIS is due to be completed by January 1989.¹²³ In a work plan prepared for this study, Dr. Weston identified a number of areas needing further research,¹²⁴ generally corresponding to the impacts discussed in the previous section.

For each impact, Weston posed questions for further research, then suggested an approach for answering these questions. For example, on the issue of sedimentation, he suggested that research should focus on the rate, extent, and predictability of sediment accumulation beneath pens, recommending these questions be answered through field surveys at existing farm sites. Weston also thought that researchers should consider techniques to minimize sediment accumulation;¹²⁵ for example, using feed/feces collection devices, instituting a system of pen rotation, or using single-point mooring so that the pens swing with the current. Since preparing the work plan, however, he has stated that many of these techniques may either not be economically feasible or environmentally sound. According to Weston, proper initial siting of the farm is much more critical than any remedial practices.¹²⁶

Groups on both sides of the farming issue welcome the idea of a generic impact study. There is disagreement over whether development of the industry should be halted in the meantime, however. This decision necessarily turns on assessment of risk. British Columbia and Washington have pursued divergent approaches to this issue.

In British Columbia, the Gillespie Commission recommended that the moratorium on issuing farm leases be lifted. Although commercial fishery groups urged that the moratorium be extended until completion of the environmental studies, the government has already begun to phase it out.¹²⁷ The Canadian approach reflects a presumption that a lack of documented, adverse impacts by existing farms means their risks are either insignificant or are manageable.

123. B. Boyle, Commissioner, Washington Dep't of Natural Resources, Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

124. Science Applications International Corporation, Final Report, Programmatic Environmental Impact Statement for Salmon Net-Pen Culture in Washington State, Work Plan and Cost Estimate (Jan. 1987).

125. Id. at 5-6.

126. D. Weston, Remarks made to Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

127. Telephone communication with Ed Black, British Columbia Ministry of the Environment, Victoria, B.C. (Nov. 12, 1986).

On the other hand, Washington has been more cautious. One citizen group has urged that long-term studies (5 years or more) be carried out before the industry is allowed to proceed,¹²⁸ and at least 3 counties have instituted a moratorium on issuing farm permits.¹²⁹ A bill will be introduced in the 1988 legislature to establish a statewide moratorium until completion of the state's programmatic environmental impact statement.¹³⁰ If Washington pursues this course, it will reflect a presumption opposite to that prevailing in British Columbia: that industry bears the burden of showing no adverse effects before proceeding.

2. Interim Steps to Reduce Risks

Enabling the industry to proceed does not mean that policymakers cannot take steps to minimize environmental risks. Sedimentation, water quality impacts, and phytoplankton growth vary widely at specific farm sites. Adverse impacts are more likely to occur where farms are located in areas of poor tidal flushing, shallow water depth, and relatively high sediment and nutrient loads.¹³¹ Obviously, siting and operational restrictions may significantly reduce these impacts.

Siting restrictions are contained in a set of "recommended interim guidelines," published by the state of Washington in February 1987.¹³² The goal of these interim guidelines is to avoid significant adverse environmental impacts from salmon farms pending preparation of the programmatic environmental impact statement on the industry. Although the guidelines do not have the force of regulations, the state has strongly encouraged local governments to conform their management programs to them.¹³³

The guidelines contain a number of recommendations for project siting, operating practices, and include an annual monitoring program. One siting guideline incorporates a graph depicting the minimum permissible water depth under a proposed pen farm, given its anticipated size and the average current velocity at the site.¹³⁴ Another guideline states that, depending on the direction of the current, minimum distances between 150 and 300 feet should be maintained between pens located in waters shallower than 75 feet and in any "habitats of special significance," such as eelgrass and shellfish beds. Complying with these siting guidelines, and also

avoiding the use of unpelletized wet fish feed, should minimize negative impacts from accumulated feed and feces.¹³⁵

To minimize the likelihood of degraded water quality or increased phytoplankton growth, the guidelines identify geographic areas in Puget Sound having chronic water quality problems. In some of these areas, the guidelines suggest limits on annual farm production; in others with low dissolved oxygen and depleted nitrogen, they recommend local governments employ a rebuttable presumption against siting any farms.¹³⁶ Finally, the interim guidelines recommend a program of environmental monitoring that includes bathymetric, hydrographic, and diver surveys before a permit may be granted, and annual surveys after the farm becomes operational.¹³⁷

Beyond siting criteria, technological approaches can reduce water quality effects. Farmers have found that the use of waste dispersing fans, suspended aprons, sediment vacuums, and planting of certain seaweeds can help prevent sediment build-up.¹³⁸ In some regions, minimum separation distances have prevented transfer of disease or degraded water quality between farms. In British Columbia, the Gillespie Commission recommended that this distance be tripled -- from the present minimum of .5 nautical miles (0.9 km) to a new minimum of 3.0 kilometers.¹³⁹

Other restrictions can reduce the introduction of exotic species and their associated diseases. In Washington, for example, importers of live smolts and exotic species must obtain permits requiring examination of the fish for disease. Except for "eyed" Atlantic salmon eggs, no live salmon or their reproductive products may be imported from Europe.¹⁴⁰ Imported Atlantic eggs must include a health history, must be disinfected, then held in a 90-day, closed system quarantine.¹⁴¹ British Columbia has similar restrictions on the importation of live salmon and fish eggs.¹⁴² In addition, a requirement that all farms be bonded could provide funds for mitigating any environmental damage.

3. Economic Incentives

Policymakers should appreciate the fact that in some instances the industry is self-motivated to protect environmental quality. Because penned salmon are extremely sensitive to water quality conditions, farmers can ill afford to degrade their environment. They therefore have strong incentives to construct, maintain, and site their pens so that dispersion and dilution

128. Brookbank, above note 92, at 2.
 129. See above note 42.
 130. Communication with Washington Representative Spanel, Olympia, Wa. (Jan. 14, 1988). See H.B. 616 introduced in the 50th Washington Leg., 1st Sess. (1987).
 131. Gillespie Report, above note 31, at 17.
 132. Washington Department of Ecology, Recommended Interim Guidelines for the Management of Salmon Net-Pen Culture in Puget Sound (1986) [hereinafter Interim Guidelines].
 133. Saunders, above note 41.
 134. Interim Guidelines, above note 132, at 3.

135. Id.
 136. Id. at 5.
 137. Id. at 8.
 138. Gillespie Report, above note 31, at 18.
 139. Id. at 38.
 140. Wash. Admin. Code § 220-77-030.
 141. See Weston Report, above note 62, at 83.
 142. See id. at 119.

of by-products are enhanced.

Economic considerations also weigh against excessive use of feed and the overuse of antibiotics. Fish food is costly, accounting for 50%-60% of a farmer's total operating expenses. The cost of treating the entire stock of a small farm with antibiotics for 10 days is around \$5000.¹⁴³

These economic realities can assist policymakers. They can supplement or, in some cases, might reduce the need for external pressure to achieve environmental protection.

4. Federal Preemption

In some cases, local regulation should be unnecessary because federal legislation already governs the area of concern. For example, salmon farms may be required to obtain a permit under the National Pollutant Discharge Elimination System (NPDES) of the federal Clean Water Act,¹⁴⁴ although the issue is not yet settled. The Clean Water Act requires "point source" dischargers of pollutants to apply to the Environmental Protection Agency or approved states for an NPDES permit.¹⁴⁵ Aquaculture facilities are considered "point sources" if they are designated as such by the Environmental Protection Agency, or if they have certain discharge, production, and feed capabilities.¹⁴⁶ The Sierra Club Legal Defense Fund believes that the pens qualify as point sources under these definitions. However, to date, the state of Washington concluded otherwise and has yet to require salmon farm applicants to seek NPDES permits.¹⁴⁷

An area where federal laws do govern concerns the issue of marine mammal control. The Marine Mammal Protection Act of 1972 (MMPA) prohibits harassing, capturing, or killing any marine mammal.¹⁴⁸ There are exceptions in the Act, however, allowing salmon farmers to take certain steps to protect their equipment or stock.¹⁴⁹ To qualify for these exceptions, a farmer must apply for a federal "certificate of inclusion," placing him under the terms of a general permit issued to commercial fishermen using stationary gear.¹⁵⁰ This certificate authorizes a farmer to use non-lethal methods, such as underwater acoustic devices, to deter marine mammals. Only if non-lethal methods have failed and the mammal is causing predation or immediate, substantial damage, may a farmer resort to methods which may cause injury or

143. Personal communication with John Pitts, Aquaculture Coordinator, Washington Dep't of Agriculture, Olympia, Wa. (Nov. 10, 1986).

144. 33 U.S.C. §§ 1251-1376.

145. 33 U.S.C. § 1342.

146. 40 C.F.R. § 122.24 and app. C.

147. Telephone communication with Stan Springer, Washington Dep't of Ecology, Olympia, Wa. (Feb. 2, 1987).

148. 16 U.S.C. §§ 1362, 1372.

149. 16 U.S.C. § 1371(2); 50 C.F.R. § 216.24.

150. 50 C.F.R. § 216.24(b)(iv).

death.¹⁵¹

IV. Socioeconomic Issues

The salmon farming industry has been identified with socioeconomic impacts that are both positive and negative. This reality challenges policymakers seeking to produce net positive results for their constituents.

A. Potential Benefits to the National Economy

Domestic production of seafood has not kept pace with the rising consumption of fish and shellfish in the United States in recent years. To meet U.S. demand, imports of foreign seafood increased 31% between 1981 and 1986.¹⁵² The U.S. fisheries trade deficit increased by 80% over that period, and in 1986 amounted to \$3.5 billion.¹⁵³ The U.S. now imports a stunning 64% of the seafood it consumes.¹⁵⁴

The production curve from commercial fisheries has flattened out. Through the end of this century, the supply of traditionally harvested seafood is expected to increase only around .3% per year.¹⁵⁵ Therefore, any correction of this imbalance will have to be made by American aquaculture.

Proponents of salmon farming contend that a strong domestic salmon farming industry would help reduce the U.S. fisheries trade deficit. One advocate predicts that 40 "typical" farms (each covering 2.5 acres and producing 250 tons of salmon per year) could entirely replace current U.S. salmon imports.¹⁵⁶ Others claim that the impact of a domestic salmon farming industry would be insignificant.¹⁵⁷ Salmon are actually only a small portion of fishery imports that are dominated by foreign cod, shrimp, and other species. Thus, replacing all foreign farmed salmon with domestically raised product would decrease the U.S. total trade deficit by less than .05%.¹⁵⁸

151. 50 C.F.R. § 216.24(d)(4); Telephone communication with Joe Scordino, Marine Mammal Coordinator, National Marine Fisheries Service, Seattle, Wa. (Mar. 9, 1987).

152. Alaska Mariculture Assoc., 1 Alaska Mariculture Report (Sept. 1987), at 3.

153. Id. at 4.

154. W. Greer, Public Taste and U.S. Aid Spur Fish Farming, New York Times (Oct. 29, 1986), at 1.

155. Dep'ts of Commerce and Economic Development and Fish and Game, Mariculture in Alaska (Jan. 1987).

156. J. Forster, General Manager, Seafarms of Norway, Port Angeles, Wa., Remarks made to a Fisheries Research Institute Seminar, above note 20.

157. J. Crutchfield, Professor, University of Washington, Remarks made to Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988). See also Schmitt, above note 1.

158. J. Brookbank, President, Marine Environmental Consortium, Remarks made to Governor's

Proponents also claim that a domestic farming industry would have an advantage in certain markets now served by imported products. American farmers would have lower transportation costs and would not be faced with import duties or currency fluctuations.¹⁵⁹ If these cost savings are passed on to consumers, the general public would also benefit from a domestic industry.

B. Potential Benefits to Regional Economies

The potential benefits to regional economies from domestic farming are quite attractive. The Gillespie Commission reported that the 70 farms in British Columbia represent a direct capital investment of \$75 million, employ 375 people, and spend \$50 million on services and supplies annually.¹⁶⁰ Reportedly, each farm in Norway creates 7-10 direct jobs and 5 indirect jobs.¹⁶¹ In 1986, the typical Washington farm employed 24 persons and had an annual payroll of about \$294,000.¹⁶² One analyst predicts that a 20,000 ton per year industry in Alaska would create around 1,920 jobs, with a payroll of \$48.8 million and \$132 million in gross sales.¹⁶³

Other analysts caution that the industry will not bring a boom in local employment or employee related income.¹⁶⁴ This is because the farms are not labor intensive and do not pay high wages. Also, when foreign capital is involved, profits will go to overseas investors.

Proponents assert that salmon farms will lead to the development of new support industries to construct farm facilities and manufacture specialized equipment. Commercial fishermen will be called on to capture non-commercial or underutilized fish for feed manufacture. Processing plants will be operated in the winter when they would otherwise be idle. Some predict that the net effect could produce a repopulation and revitalization of rural coastal areas.¹⁶⁵

C. Projected Downturn of the Industry

For a region to enjoy these benefits, of course, its salmon farming industry will have to be viable. According to some forecasts, however, the industry will face an economic downturn at the end of this decade, caused by increases in the cost of fish food and by the infusion of large quantities of farmed salmon expected to be on the market in the late 1980's

and early 1990's. In British Columbia alone, farms are expected to at least quadruple their current production;¹⁶⁶ in just 2 years, farmers there expect to market nearly 20,000 tons of farmed Pacific salmon.¹⁶⁷

Many analysts believe that there will be insufficient demand for these fish, markets will become saturated and, consequently, prices will fall. One analyst predicts that prices paid to British Columbia farmers, which now stand at \$4.00 to \$6.00 per pound (U.S. dollars),¹⁶⁸ will fall to less than \$3.00 per pound.¹⁶⁹ Another predicted that the price may drop 30% by 1989.¹⁷⁰

This decline will probably force less efficient producers out of business. The smaller farms will be more vulnerable; according to one forecast, farms producing less than 500 tons per year will not have enough volume to remain profitable.¹⁷¹ Downward price pressure will prompt mergers, and the resulting industry will consist of fewer, but larger enterprises.¹⁷²

This forecast may create a dilemma for policy makers. Farming opponents argue against devoting scarce public resources to an industry on the verge of collapse. They argue that industry growth should be discouraged, to avoid attendant socioeconomic problems.¹⁷³ On the other hand, the main financial risk will be assumed by the private sector. True, the government will incur the expense of regulating the industry, but much of this can be recovered from user fees and taxes. In Washington, for example, a bill which would tax farmers \$.0125 per pound of marketed fish is currently before the legislature. Most of the revenue from this tax will be passed on to local governments to defray their costs of regulating and monitoring.¹⁷⁴

Certain policies could reduce the risk of public exposure of industry failure. To avoid unnecessary expenditures and duplication, policy makers could suggest that farmers use the excess capacity of existing processors, existing trans-

Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

159. B. Paine, Marketing Norwegian Farmed Salmon, 1 Alaska Mariculture Report no. 5 (Jan. 1987), at 5.

160. Gillespie Report, above note 31, at 28.

161. Id.

162. Pitts, above note 95.

163. B. Pierce, Aquaculture in Alaska, Alaska Legislature, House Research Agency Rep. (Feb. 1987), at 87-B.

164. Crutchfield, above note 157, at 36. See also Schmitt, above note 1.

165. Moore Remarks, above note 88.

166. The anticipated 1988 production in British Columbia is 5,000 tons. A. Archibald, British Columbia Salmon Farmers Assoc., quoted in 2 Alaska Mariculture Report, no. 2-3 (Dec. 1987-Jan. 1988), at 4.

167. Telephone communication with Nelles, above note 21.

168. Id.

169. Lipovsky, above note 20.

170. R. Tjelta quoted by S. Gilje, B.C. Takes Fish Farming Hook Line and Sinker, Seattle Times (Oct. 4, 1987) at D-1.

171. Fish Farming International, Surplus Salmon Warning -- Production May Exceed Demand by 23,000 Tons (Dec. 1986).

172. Lipovsky, above note 20.

173. See H.B. 103 and S.B. 106, 15 Leg., 1st Sess. (1987) (written testimony of Alaska Trollers Assoc., Juneau, Ak. (Feb. 16, 1987)).

174. Communication with Rep. Haugen (Jan. 14, 1988); see H.B. 54, 50th Leg., 1987 Reg. Sess.

portation services, and existing marketing channels. By requiring surety bonds of new farmers, policy makers can ensure that funds are available to dismantle or otherwise deal with abandoned farms.

Practically speaking, periodic "shakeouts" are commonplace in fast developing, product-driven industries, particularly during their early years. The loss of inefficient producers is a necessary and positive step in this evolution. There is little doubt that the salmon farming industry, in some form, will survive the anticipated "crash of '89." Thus, the real issue ought to be one of formulating policies to ensure that the region has healthy survivors. Consequently, policy makers should institute programs to strengthen the competitive posture of local farms. This approach can be effective if government efforts are directed at particular problem areas for the local industry.

In Norway and Maine, a limiting factor on the industry is the shortage of healthy smolts. In the former, pen-ready salmon have been imported from Scotland to keep the farms at full capacity; this has caused disease problems, however.¹⁷⁵ Reportedly, the lack of smolts was a major factor inducing Norway to enact a recent moratorium on licensing new farms.¹⁷⁶ Smolt shortages can be alleviated if smolts for the farming industry are produced in public salmon hatcheries currently used to enhance naturally spawning stocks. This is in fact now being done in British Columbia. With enabling legislation, it could also be accomplished in Alaska, which presently has 20 state-owned and operated salmon hatcheries.¹⁷⁷

Another limiting factor in some areas is the unavailability of high quality fish food. This problem could be addressed by policies encouraging (1) the development of fish food manufacturing plants, and (2) local harvesting of noncommercial and underutilized species to supply these operations.

In British Columbia, some analysts believe that biotechnical factors will prove to be the most significant impediment to the growth of salmon farming. They call on the government to expand genetic selection programs, nutrition, and disease research.¹⁷⁸ To address the disease problem, the province recently hired a veterinarian to service the industry.¹⁷⁹

If insufficient demand causes the expected market downturn, efforts to develop new markets and expand current ones will be obviously necessary to diminish, if not overcome this problem. Some industry analysts believe that the most important factor in the success of the Norwegian industry has been the development of a nation-

wide marketing organization. Since 1978, the government has required all farmers to join and fund a Fish Farmers Sales Organization, which establishes and implements quality controls and channels its members' exports through approved exporting companies. More important, the organization furnishes farmers with current market information and promotes consumption of Norwegian-farmed salmon.¹⁸⁰

In British Columbia, the Gillespie Commission concluded that national associations are necessary, and it urged the province to support a strategy for integrated marketing of both traditionally harvested and farmed salmon. This support would include financial assistance, trade missions, and the transfer of technology.¹⁸¹ Already, the government has funded marketing studies by the regional salmon farmers' association and awarded a 3-year grant to assist export-marketing activities.¹⁸²

Finally, policymakers should recognize that a reputation for consistency and high quality has enabled farmed salmon to compete successfully in the world market. Norway's success has been attributed in part to the rigid grading and quality control standards which the government imposes on the industry.

D. Maximizing Benefits to Local Economies

Many analysts believe that efforts should be taken to direct the benefits of the industry to local residents.¹⁸³ There is fear that the salmon farming will become a form of "agribusiness," characterized by large corporations, foreign investors and managers, and profits that leave the region. This is a particular concern in Alaska, whose resources have historically been managed and exploited by forces outside of the state.

Some suggest that the physical size of farms ought to be limited,¹⁸⁴ or the output of individual farms restricted. There are also suggestions that prohibit vertical integration of farms, or limit their ownership to local residents. Norway has taken the lead in this area also, placing size and participation restrictions on the farms, effectively using the industry to foster social policies unrelated to food production. Although it does not prohibit vertical integration, Norway limits the size of farms to 8000 cubic meters of enclosed water volume and requires that 50% of the ownership of

175. Paine, above note 159, at 49.
176. Letter from Weston, above note 59.
177. Pierce, above note 163, at 23.
178. DPA Group, above note 7, at 7.
179. Personal communication with Pitts, above note 143.

180. See Paine, above note 159.
181. Gillespie Report, above note 31, at 35.
182. *Id.* at 14.
183. P. Crocker Davis, Washington State Coordinator, Audubon Society, Remarks made to a Fisheries Research Institute Seminar, above note 20.
184. One proponent stated that small operations are more desirable because they are more flexible and innovative in the marketplace. D. Swecker, President, Washington Fish Growers Assoc., Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

a farm be held by local residents.¹⁸⁵ This has produced an industry composed of relatively small operations -- about 8 net-pens each.

This policy has some drawbacks. Some farmers believe that restrictions on farm size lead to high fish density in the pens. This, in turn, increases the potential for disease.¹⁸⁶ The size restriction has also driven potential investors overseas. One of the principal beneficiaries has been British Columbia, where approximately 40% of the total capital invested in the industry comes from foreigners. Norwegian capital is involved in 10 of the 11 British Columbia farms with foreign investment.¹⁸⁷

Because local institutions have proved reluctant to extend credit to the new industry, the Canadians believe that foreign capital is necessary to get the industry on its feet. They believe that foreign investment is less threatening because, so far, it has taken the form of shared equity; typically, foreigners assume partnership roles with existing owner-operators rather than take full control of the farms.¹⁸⁸

Restrictions on vertical integration also seem to be inconsistent with British Columbia's business philosophy, which tends to be a laissez faire approach to development of the industry. Due to cost efficiencies, analysts view the trend toward vertical integration of larger farms in Norway as a positive one, where about one-third of the permits are held by farms with associated hatchery operations.¹⁸⁹

Restrictions on farm size conflicts not only with the industry's trend toward larger multi-site farms, but also with financial reality. While the concept of an industry built of small "mom and pop" operations may seem attractive, it may be impracticable given the relatively high initial investment -- estimated to be about \$1 million -- needed to start a viable farm. Even if smaller, owner-operated enterprises take hold, they will likely be highly vulnerable to industry downturns.

In addition to fiscal problems, there may be important legal constraints to attempts to limit investment to local residents. American policymakers should be particularly cautious, because such restrictions may violate equal protection clauses of federal and state constitutions or, in the case of out-of-state residents, the privileges and immunities clause of the U.S. Constitution.¹⁹⁰

E. Impact on Domestic Commercial Fisheries

The established salmon industry, based on a resource captured in the wild, fears that growth of the farming sector will create a strong competitive threat to traditional markets. This concern is probably the major impediment to salmon farming in Alaska where, in 1985, 90% of the U.S. harvest occurred -- about 43% of the total world harvest.¹⁹¹

1. Potential Impact on U.S. Domestic Markets

Adverse effects of farmed salmon on domestic markets may be mitigated by the increasing demand for seafood products. American consumption of seafood grew by 21.5% between 1982 and 1985.¹⁹² Per capita consumption in this country now stands at about 15 pounds per year.¹⁹³ Industry analysts predict that by 1990, consumption of seafood will increase to about 20 pounds per person annually.¹⁹⁴

Because the amount of traditionally harvested fish is not expected to increase by more than 1/2% each year during this period,¹⁹⁵ fishermen could expect higher prices for their product. However, salmon fishermen are concerned that salmon farmers will satisfy a large portion of this rising demand.

Indeed, the amount of foreign farmed salmon exported to U.S. markets is expected to increase significantly. In 1983, the United States imported 1768 tons of farmed Atlantic salmon from Norway, the largest foreign supplier.¹⁹⁶ By 1985, this figure had increased nearly fourfold, to 6460 tons; by 1990, it is projected to triple again, to 20,000 tons.¹⁹⁷ British Columbia is expected to contribute up to 20,000 tons,¹⁹⁸ and Chile, Scotland, and New Zealand are all anticipating major increases in their exports of farmed salmon to the United States.¹⁹⁹

By comparison, these imports fall well below the total Alaskan harvest of all 5 Pacific species, which was 333,763 tons in 1985. However, they do surpass the 1985 catch totals of traditionally harvested Alaskan chinooks and cohos, the two species expected to bear the greatest impact from any competition by farmed Atlantics.²⁰⁰ None of these figures include any expected production increases by American farms. The supply-demand-price picture for salmon is

185. Communication with H. Ibrekk, Research Engineer, Norwegian Institute for Water Research, Seattle, Wa. (Jan. 15, 1987).

186. Moore Remarks, above note 88.

187. DPA Group, above note 7, at 7.

188. Gillespie Report, above note 31, at 21.

189. DPA Group, above note 7, at 6.

190. U.S. Const. amend. XIV, § 1.

191. Pierce, above note 163, at 5.

192. Alaska Mariculture Assoc., *Alaska Mariculture and Seafood Markets* (Feb. 1987), at 1.

193. Greer, above note 154.

194. P. Parker, Remarks made before a seminar entitled "State of the Seafood Market," Pacific Marine Expo, Seattle, Wa. (Nov. 20, 1986).

195. Alaska Mariculture Association, above note 192.

196. NMFS Outlook, above note 19, at 42.

197. Rogness & Lin, above note 9, at 1.

198. Nelles, above note 21.

199. Rogness & Lin, above note 9, at 3.

200. *Id.*

further complicated by probable growth in the production of other aquaculture products, such as shellfish and catfish. Furthermore, hatcheries in the Pacific Northwest plan to release 2.6 billion salmon by 1900, an increase of 245% over an 8-year period.²⁰¹

Fishermen are concerned that aquaculture will damper an expected upward price trend for their fish. If aquaculture production is large enough, they fear that prices may even be driven down.²⁰² Thus, the issue for Alaska and other salmon fishing regions is whether greater numbers of farmed salmon will create new markets as demand for seafood rises, or whether they will compete as substitutes in the markets now served by traditionally harvested salmon. There is very little consensus or research on this question.

Proponents of salmon farming claim that because of year-round availability of high quality salmon, new consumers will develop a taste for salmon, translating into greater demand for all salmon, including traditionally harvested. Farmers claim that fresh farmed salmon, because it commands a higher price than traditionally harvested salmon, will have a leveling effect on price fluctuations, helping to maintain a higher price for all salmon. There is little research supporting this theory, however.

Recently, researchers Ronald Rogness and Bing-Hwan Lin presented preliminary findings from what is probably the first systematic study of this issue. As part of an ongoing project entitled "Economic Impact of Farmed Salmon Upon the Alaskan Commercial Fishing Industry," Rogness & Lin surveyed seafood marketers.²⁰³ Although the response rate was a relatively small 24%, replies at the wholesale level may reveal the potential for competition at the retail level. The researchers' most important finding was that a substantial majority -- 79% of the wholesalers and distributors -- believe that fresh-farmed Atlantics are a legitimate substitute for fresh Pacific salmon. There seems to be less potential for competition when either product is marketed in a frozen state. In any case, the Alaskan fishermen who stand to lose are those who troll for cohos and chinooks, and those who gillnet for sockeyes on Alaska's Copper River.²⁰⁴

This survey has been cited by both advocates and opponents of the industry. Salmon trollers say that it confirms their belief that farmed fish do compete with harvested fish in the marketplace. Supporters of the farming industry argue that trollers accounted for less than 4% of the total value of Alaska's 1985 salmon production.²⁰⁵ Rogness and Lin concluded that because only 3% of Alaska salmon is marketed

fresh, the concerns of most Alaskan salmon fishermen are largely unwarranted.²⁰⁶

Another response to the survey confirms the seasonal marketing pattern of imported Atlantics. Since Pacific salmon enjoy a price advantage over the farmed fish, the latter have historically been marketed in the off-season, when fresh Pacific salmon are not available, and the fresh Atlantics can command their premium price. Most marketers plan to maintain this pattern, which fishermen may find encouraging. However, over 80% of them also intend to market more Atlantics than they have in the past.²⁰⁷ This means that although most farmed Norwegian salmon will continue to enter the market during the off-season, more Atlantics than at present will be entering during the prime market season for harvested salmon.

A cause for further concern may be the reported pattern of farmed imports from Canada. According to a 1984 study, these imports coincide with the commercial fishing season and are priced more competitively with traditionally harvested salmon.²⁰⁸ However, while the price of farmed salmon varies according to season and source, it generally it has been offered at about 60% to 75% higher than the price of traditionally harvested salmon, a significant difference in the competitive domestic marketplace.

2. Potential Impact on European Markets

A substantial portion of the Pacific salmon likely to be affected by farmed Atlantics -- that is, troll-caught cohos and chinooks -- are frozen and sold during the winter months to European smokehouses. Although the European market accounted for only 12% of the value of U.S. salmon exports in 1983, many analysts believe this market will be the source of the most competition between these products.²⁰⁹ American fishermen are at a disadvantage in the European market when competing against Norwegian farmed salmon which not only have a closer source, but are capable of being delivered in custom quantities and sizes.

In fact, salmon trollers claim that they have already been pushed out of the frozen market in Europe.²¹⁰ Some figures seem to support this conclusion. Over the 1979-1983 period, Norway's exports to EEC countries rose by 193%. During this time, American exports of frozen wild salmon increased by only 5%.²¹¹ By 1984, farmers supplied 38% of the salmon used by smokers in the United Kingdom, more fish than supplied either by salmon gillnetters or trollers.²¹²

201. NMFS Outlook, above note 19, at 35.
202. *Id.* at 2.
203. Rogness & Lin, above note 9.
204. *Id.* at 6-7.
205. Alaska Mariculture Association, above note 192.

206. Rogness & Lin, above note 9, at 6.
207. *Id.* at 13.
208. NMFS Outlook, above note 19, at 40.
209. *Id.*
210. Telephone communication with Glen Aurdahl, Washington Trollers Assoc. (Jan. 12, 1987).
211. NMFS Outlook, above note 19, at 9.
212. K. Ringstad, untitled document present-

Fishermen believe that these expanding imports are responsible for the fact that prices for troll-caught salmon have declined from about \$3.00 to \$2.50 per pound during the past several years.²¹³ According to testimony before the Gillespie Commission, however, these declines are well within the range of normal price fluctuations experienced by the salmon industry.²¹⁴

Currently, frozen Pacific salmon enjoys a price advantage in the U.S. market, and the difference may be critical to maintaining the fishermen's position. This advantage, of course, is vulnerable to fluctuations in the exchange rate between U.S. and European currencies.

Farmed salmon, on the other hand, enjoy a reputation for high and consistent quality. After "year-round availability," the respondents to the Rogness-Lin survey rated "freshness" and "consistency" as advantages which farmed Atlantic salmon have over traditionally harvested salmon.²¹⁵ These advantages have pressured the traditional industry to improve the quality of its product. In the processing sector, there are calls for more uniform grading standards and more consistent labeling terminology. In the harvesting sector, fishermen are promoting better on-board chilling, dressing and handling of salmon.²¹⁶

Researchers recently studied the feasibility and economic impact of salmon farming in Alaska. Based upon pessimistic assumptions that the demand for salmon will not increase over time, that farmed and traditionally harvested salmon directly compete in the marketplace, and other assumptions that they admitted were contrary to recent experience, Logan and Weddleton presented a worst case scenario for commercial salmon fisheries. The study projected a \$36.4 million loss to Alaska fishermen from out-of-state farming efforts. If the industry were permitted to develop, its in-state farm production would cause an additional \$4.7 million loss to fishermen, but would generate \$132 million in direct sales.²¹⁷

3. Policy Responses to the Competition Issue

Before one can conclusively decide whether farmed salmon present a significant economic threat to the capture fishery, more research is needed. The Rogness-Lin survey was intended to be a first step in a larger study of this issue. Unfortunately, according to the two researchers,

ed to Norwegian Trade Commission Fish Farming Seminar, held in Seattle, Wa. on June 5, 1986, at 2.

213. Telephone communication with Aurdahl, above note 210.

214. Gillespie Report, above note 31, at 12.

215. Rogness & Lin, above note 9, at 14.

216. Telephone communication with Doug Fricke, President, Washington Trollers Assoc. (Dec. 1, 1986).

217. R. Logan & J. Weddleton, Salmon Farming in Alaska - Economic Feasibility and Socioeconomic Impact (1987).

their study may not proceed beyond this step.²¹⁸ The survey furnished an indirect gauge of consumers' attitudes toward traditionally harvested and farmed salmon in their various forms. The next step should be a direct assessment of these attitudes. This is crucial for the European market, which has not been examined by even a preliminary survey. It will also be important to gauge market attitudes toward farmed Canadian salmon as it begins to enter markets.

Further research should focus on the two features that most clearly distinguish the products -- quality and price. As the fishing industry directs its efforts toward higher and more uniform quality, it will be important to determine the demand elasticities of variations in quality.

Competition between farmers and fishermen will press prices downward. Researchers need to examine production costs in order to predict which segment of the industry can better absorb price reductions. If the price disparity between farmed and traditionally harvested salmon changes, it will be important to discover the demand elasticities of this feature as well. Should the price squeeze become acute, fishermen may be forced to consider radical changes in present harvest methods that have become very capital, energy, and labor intensive.

If research shows that there is harmful competition, one policy option would be to discourage the development of a domestic farming industry and actively promote harvested fish over the farmed product. The latter is the approach now being taken by the Alaska Seafood Marketing Institute, a joint industry-government association promoting consumption of Alaskan seafood. In 1986, the institute developed a program that places "zero defect," individually-labeled traditionally harvested salmon in the restaurant trade traditionally served by Atlantic salmon. The institute's marketing theme emphasizes an alleged superior flavor, color, and firmness of its "naturally wild" product.²¹⁹

A less divisive policy would encourage a formal communication link between the two groups. If both are operating in the same region, there may be common grounds for cooperation. A shared market strategy against competitors in the food market may be one area of common effort. Even if the two components of the industry do not become cooperative, a formal communication link would promote understanding and perhaps diffuse unnecessary tensions.

Another policy alternative would encourage commercial fishermen to become salmon farmers themselves. This is not without precedent; re-

218. Telephone communications with Dr. Bing-Hwan Lin, University of Idaho (Dec. 15, 1986) and with Ronald Rogness, North Pacific Fisheries Management Council (Jan. 12, 1987).

219. Telephone communication with William Woolf, Alaska Seafood Marketing Institute, Juneau, Ak. (Nov. 28, 1986).

portedly, one of the most successful aquaculture groups in British Columbia is the Prince Rupert Fisherman's Cooperative, whose members include fishermen operating the farms and marketing pen-cultured salmon during their off-season. The cooperative is an example of how fishermen can take part in the new industry.²²⁰

There are also reports, however, that this idea does not appeal to many fishermen. In testimony before the Gillespie Commission, British Columbia fishermen often expressed a philosophical preference for being "high seas hunters," in contrast to what they viewed as the isolated, low paid life of a farmer.²²¹

V. User Conflict Issues

Depending on their location, net-pens may offend upland owners or may compete with other coastal users. Among those affected are owners and occupiers of upland property, commercial fishermen and vessel operators, sport fishermen, boaters, and other recreational users.

A. Impact on Upland Users

Many upland owners and occupants strongly object to the visual impact created by net-pens. This is a very divisive issue in Washington's Puget Sound, where many residents have invested in waterfront properties for second and retirement homes with the expectation of enjoying unobstructed, natural views. Upland owners fear that salmon pens along their shorelines will decrease property values. Although some realtors suggest that this may be the case, there is no concrete evidence of this effect, probably because there have not been enough transfers of lots adjacent to net-pens to permit an evaluation.²²²

The upland landowner issue receives less public attention in Norway, where the majority of farmers are the tenants or owners of the adjacent uplands.²²³ Probably because of lower residential densities and more dispersed public use, aesthetics also seems to be less of a divisive issue in British Columbia.²²⁴ In Maine, a court recently held that the state does not have to consider a project's effect on adjacent property values when deciding whether to grant an aquaculture lease.²²⁵

B. Conflict With Water Users

Fishermen, boaters, and other water users worry that salmon pens will restrict access to open anchorages, lucrative fishing sites, and favorable navigation passages.²²⁶ Maine specifically requires that user conflicts be considered in its permitting process, and the Maine statute may be a good model for dealing with this issue. Under Maine's permitting law, the Commissioner of Marine Resources may grant an aquaculture lease only if the proposed project will not unreasonably interfere with access by riparian owners or with navigation, fishing, or with public use near public beaches, parks, or docking facilities.²²⁷

C. Policies to Mitigate User Conflicts

The issue of aesthetic impact represents a difficult challenge for policymakers. Aesthetic concerns are rarely expressed as such: adjacent land owners often voice their opposition to net-pens in terms of concern for the environment, rather than in terms of aesthetics.²²⁸ Perhaps this is because many people believe that aesthetic grounds are less legitimate or overly subjective. Unless the effect can be measured by a decrease in property value, it is difficult to quantify the probability or the degree of visual impact. As one administrator observed, the offense is "in the eye of the beholder," and mitigation is difficult because many opponents will not be satisfied so long as there is one net-pen within their view.²²⁹

Nevertheless, a recent publication by the Washington Department of Ecology may offer some help. Entitled "Aquaculture Siting Study," this report analyzed several components of visual impact -- landscape setting, the number of viewers and their duration of view, and the siting and design of the proposed aquaculture facility.²³⁰ The study supplied a step-by-step method for classifying the visual effect of a project into one of 4 categories, from low impact to severe impact,²³¹ and suggests appropriate siting standards. In terms of landscape features, the study stated that an optimum site should have low shoreline banks, existing commercial marine activity, and no residences. To further mitigate visual impacts, the study recommended that pens not be located closer than 1500 feet from

220. Pierce, above note 163, at 69-70.

221. Gillespie Report, above note 31, at 27.

222. Brookbank, above note 92.

223. Pitts, above note 143.

224. Gillespie Report, above note 31, at 25.

225. *Harding v. Commissioner of Marine Resources*, 510 A.2d 533 (Me. 1986). (Plaintiff Harding appealed the Department of Marine Resources' refusal to consider evidence of a proposed aquaculture project's effect on the value of his adjacent waterfront property. The Knox County Superior Court held for the plaintiff, vacated the project's leases, and remanded for presentation of evidence on the issue. The Supreme Court of Maine reversed the lower court, deciding that neither the state statute, Me.

Rev. Stat. Ann. tit. 12, § 6072(7), which contains a narrow list of factors that must be considered for leasing an aquaculture site, nor the common law public trust doctrine required the commissioner of that department to additionally consider the effect of the proposed project on adjacent property values.)

226. Gillespie Report, above note 31, at 24-25.

227. Me. Rev. Stat. Ann. tit. 12, § 6072(7-A).

228. Pitts, above note 143.

229. *Id.*

230. Washington Dep't of Ecology, *Aquaculture Siting Study* (1986), at 61-65.

231. *Id.* at 68-82.

shore. It also suggested that the pens be colored blue or green to blend with the water, and that their vertical profiles be minimized.²³²

To prevent many of these user conflicts, the Gillespie Commission recommended that British Columbia undertake a shoreline planning program.²³³ In response, the British Columbia government has initiated a "coastal resource identification study." Using map overlays which indicate competing interests, this study will lead to a prohibition or a limitation of aquaculture in those sites which have a high value for other uses.²³⁴ Also, the Commission recommended that farmers be required to designate public anchorages, and access corridors across their leaseholds.²³⁵

VI. Permitting Issues

When developing a permitting system, policymakers must resolve 2 issues. The first is whether they should preplan their coastal areas into geographic zones of preferred use. British Columbia's "coastal resource identification study"²³⁶ is a first step toward this type of system. In Washington, it has been suggested that counties use their local zoning powers to pre-plan their shorelines.²³⁷ However, according to a recent attorney general's opinion, the state's Shoreline Management Act may have preempted any local efforts in this area.²³⁸

The alternative is to deal with each application on a first impression, case-by-case basis. There are trade-offs with each approach. A pre-planned system can prevent undue effort and cost by alerting prospective farmers to areas that are "out of bounds." On the other hand, the case-by-case system can furnish policymakers with more detailed, current information about specific sites -- information that might be missed with a one-time, large scale planning effort.

The second issue requires policymakers to allocate permitting authority between regional and local governments. They must strike a balance between a regional interest in developmental policies that are uniform and the traditional role of local government in land use planning. Currently, this is a contentious issue in Washington state. There, coastal counties with initial authority over farm applications resent having their decisions examined by *de novo* review when appealed to the state's shorelines hearing board.²³⁹

Currently, each region takes a different approach to the procedural and substantive standards that govern the permits.²⁴⁰

A. British Columbia

In British Columbia, aquaculture sites can be obtained by permit, license or lease. For most permits, applicants deal with the province rather than with the local or federal government.

A potential farmer seeking a permit for a proposed site must submit a comprehensive plan revealing his management strategy and the farm's expected production. Once the province approves the production plan, the applicant receives a "section 10" license, allowing the potential farmer to occupy and conduct research at a particular site for a year.²⁴¹ No improvements or actual farming can be conducted under this permit.

Once the site investigation is completed, the farmer may apply for site tenure. This permit, called a "license of occupation," allows the applicant to occupy the site for 10 years and to begin actual farming. For longer occupancy or where substantial improvements are planned, the salmon farmer may apply for a 20-year, foreshore lease from the government.²⁴²

The Gillespie Commission suggested several changes to this system. Generally, it recommended greater coordination and cooperation between the various levels of government, and the designation of one agency in each level as the "lead agency" on aquaculture matters.²⁴³

In response to these and other recommendations, the province has proposed significant changes to its permitting system, and these proposals are currently undergoing public review and comment.²⁴⁴ To prevent reported abuses of the "section 10" permits, they will be renamed "investigative permits," will not be renewable, and will not be able to be used solely to reserve a site for future development. An initial lease will be available for 10 years, and a replacement lease will be available for an additional 20 years. The permit fee will be \$500 and the annual rent for licenses and leases will be based on a percentage of the land value, with a minimum rental of \$500 and discounts for the initial 3 years of operation. Further, while a development plan will still be submitted with applications for a license or lease, the plan

232. *Id.* at 67.

233. Gillespie Report, above note 31, at 40.

234. M. Coon, above note 27.

235. *Id.* at 46.

236. See above note 234 and accompanying text.

237. A. Moss, Attorney, Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

238. See above note 42.

239. P. Cowan, Commissioner, San Juan County and R. Beam, Shorelines Administrator, Kitsap

County, Remarks made at Governor's Aquaculture Conference, Tumwater, Wa. (Jan. 30, 1988).

240. The author was unable to obtain any information on Norway's permitting policy.

241. Gillespie Report, above note 31, at 2.

242. Pierce, above note 163, at 68.

243. Gillespie Report, above note 31, at 45.

244. The proposal will amend Section 3.2.0400-A of the British Columbia Land Administration Manual. Telephone communication with T. Cockburn, British Columbia Ministry of Lands and Forests, Victoria, B.C. (Feb. 5, 1988).

need no longer include the farmer's management strategy. Finally, the province will require a cleanup bond with a minimum value of \$1,000.

B. Washington

Washington places initial responsibility for issuing aquaculture permits at the local level. Under the state's Shoreline Management Act of 1971,²⁴⁵ all cities and counties must adopt a local shoreline management program and administer a permit system for substantial development projects along their shorelines.

The state, through the Department of Ecology, approves local management programs and rules on any development permits, including aquaculture permits, which require conditions on their use or require variance from the local program. Challenges to the grant or denial of a shoreline permit are first heard by the state's Shorelines Hearing Board.²⁴⁶ Appeals from this quasi-judicial body are made to the state's Superior Court.²⁴⁷

Once an applicant receives a shoreline permit and permits from the state Department of Fisheries,²⁴⁸ the Department of Ecology,²⁴⁹ the Department of Agriculture,²⁵⁰ and the U.S. Army Corps of Engineers,²⁵¹ he can negotiate an aquatic lands lease with the Department of Natural Resources. These leases have a term of up to 10 years and, under certain circumstances, can be transferred, renewed, or revoked by the state.²⁵² For the first 3 years, annual lease

fees are \$250 per submerged land acre; thereafter, the fees may be negotiated or may be calculated by a statutory formula based on the commercial value of the uplands.²⁵³

C. Maine

The Maine Department of Marine Resources acts on all aquaculture lease applications.²⁵⁴ It first determines if the applicant has the financial and technical capability to carry out the planned activity.²⁵⁵ If so, the state conducts an adjudicatory hearing under its Administrative Procedure Act after notifying riparian owners, local officials, and other interested parties.²⁵⁶ Before the hearing, the Department also assesses the proposed site to determine possible impacts on the environment and on traditional fisheries.²⁵⁷

As discussed earlier, the criteria for issuing a lease are based upon potential interference with upland and other marine users. The applicant must also show that there is an available source of salmon smolt.²⁵⁸ If a riparian owner or a fisherman who has traditionally fished there wishes to lease the same area, that person will have priority over the aquaculture applicant.²⁵⁹ The leases cannot exceed a term of 10 years and, under certain conditions, are transferable, renewable, or revokable.²⁶⁰ Lease tracts are limited to 5 acres, but a lease may cover several contiguous tracts totaling up to 100 acres. However, no individual may lease more than 150 acres.²⁶¹

D. Alaska

Since Alaska statutes do not yet allow salmon farming, there are no procedures or standards which specifically apply to the industry. However, recent legislation which placed a moratorium on permits for salmon farming did authorize the development of shellfish aquaculture in the state.²⁶² The Department of Fish and Game

245. Wash. Rev. Code, § 90.58.

246. *Id.* §§ 90.58.180(1)-(4).

247. *Id.* § 90.58.180(5). Telephone communication with William Harrison, Administrative Judge, Washington Shorelines Hearing Board (Feb. 24, 1987).

248. Applicants must register, be certified for the fish disease control program, and obtain a hydraulic project approval from this department. Wash. Rev. Code. §§ 75.20.100, 75.58.

249. Applicants must obtain a statement of consistency with the Coastal Zone Management Act (16 U.S.C. § 1456(c)), a water quality certification (33 U.S.C. § 401; Wash. Admin. Code § 173-225), a water quality standards modification (Wash. Rev. Code § 90.48; Wash. Admin. Code § 173-201), a National Pollutant Discharge Elimination System (NPDES) Permit (33 U.S.C. § 1342; Wash. Rev. Code § 90.48).

250. Applicants must obtain an aquacultural identification of private sector products permit from this department. Wash. Rev. Code § 15.85.

251. Permits for obstructions to navigable waters are required by § 10 of the Rivers and Harbors Act, 33 U.S.C. § 403; discharges of dredged or fill material in all waters of the United States require a permit under § 404 of the Clean Water Act, 33 U.S.C. § 1344.

252. Wash. Rev. Code §§ 79.90.460(a), 79.90.495; Wash. Admin. Code § 332-30-161. The Washington permitting process can be both expensive and time consuming. According to one study, the permit process can take up to a year, and a conservative estimate of the cost is

\$50,000 to \$125,000. Alaska Mariculture Assoc., 2 Alaska Mariculture Report 1 (Nov. 1987), at 5.

253. These are current unpublished policies of the Department of Natural Resources. Telephone communication with Ron Holtramp, Washington Dep't of Natural Resources, Olympia, Wa. (Feb. 5, 1988); Telephone communication with John Demeyer, Washington Dep't of Natural Resources, Olympia, Wa. (Mar. 10, 1987).

254. The procedures and criteria for Maine aquaculture leases are contained in Me. Rev. Stat. Ann. tit. 12, § 6072.

255. Me. Rev. Stat. Ann. tit. 12 § 6072(5).

256. *Id.* § 6072(6). The Maine Administrative Procedure Act is at Me. Rev. Stat. Ann. tit. 5 ch. 375.

257. Me. Rev. Stat. Ann. tit. 12 § 6072(5-A).

258. *Id.* § 6072(7-A).

259. *Id.* § 6072(8).

260. *Id.* §§ 6072(2), (11), (12), (12-A).

261. *Id.*

262. S.B. 297, 15th Leg. 1st Sess. (1987), ch. 70, 1987 Alaska Sess. Laws.

and the Department of Natural Resources are currently developing a permit system for shellfish farmers.²⁶³ With minor adaptations, this system could accommodate permitting salmon farms, if the industry is ever allowed in Alaska.²⁶⁴

VII. Conclusion

During the past 15 years, pen culture of salmon has rapidly developed into an international industry. This growth is expected to continue into the 1990's. By then, one analyst predicts that farmed product will dominate the world trade of both fresh and frozen salmon.²⁶⁵ This growth will prompt debate over the farming industry's impact on the biology, socioeconomics, and competing uses of the coastal system. Public officials will be called upon to formulate policies that wisely and effectively address these issues.

As the debate begins, policymakers could focus on the experience of 5 jurisdictions surveyed in this Memo. Because of their past history, present status, or future potential, Norway, British Columbia, Washington, Maine, and Alaska constitute significant laboratories. Policies developed in these regions give administrators contrasting approaches to governing the industry in its various stages of development.

Probably the most persistent controversies will be those dealing with the marine environment. The Weston Report²⁶⁶ furnished a valuable survey of existing studies on this issue, clarifying areas in need of further research. Many answers could be forthcoming from Washington's statewide study of industry impacts.²⁶⁷

An important issue is how to govern salmon farming during the interim. The options range from British Columbia's laissez faire approach to the arrested development approach of local governments in Washington. Perhaps a legitimate policy would be a compromise between the two. According to Weston, many impacts are predictable and can be mitigated by siting restrictions.²⁶⁸ The more problematic ones can be minimized by precautionary farming practices, such as reducing the use of toxic substances and antibiotics and controlling the introduction of non-native species.²⁶⁹

Because international research has failed to identify environmental impacts that are certain,

significant, and irreversible, an absolute ban on the industry's growth is probably not warranted. Instead, a policy of closely controlled development, including siting, precautionary farming practices and environmental monitoring to supplement ongoing research, would seem more appropriate. Such a policy should account for the industry's impact on local economies and social well-being. Although the potential for enhancing rural economies seems promising, forecasters predict that the industry will experience declining prices during the next several years.²⁷⁰ This economic risk, of course, will be borne primarily by the private sector, so perhaps the role of government is to let the marketplace operate.

The established success of the farming industry suggests that any expected price downturn will probably not destroy its long-term viability. Rather than imposing restrictions on who can participate or how large their farms can be, perhaps policy makers should direct their attention toward ensuring that local farmers are the survivors when the industry consolidates in the mid-1990's.

In regions with commercial salmon fisheries, officials will be pressured to enact policies which protect fishermen from market competition from farmers. Whether farmers compete or complement the efforts of fishermen cannot be conclusively answered. Further research is needed on cause-and-effect relationships as the two products move through the same market.

Even if significant competition between traditionally harvested and farmed fish exists, protective policies will not necessarily insulate local salmon fishermen from market pressure by farmers. As the Gillespie Commission observed, local efforts to minimize competition will have little effect on the price of harvested salmon, since competition from farmed products raised beyond local borders would occur in world markets nevertheless.²⁷¹

According to others, the issue for Alaska and other regions with developed commercial salmon fisheries involves a choice between two futures: One is a future without salmon farming, but perhaps with a lower level of employment and income. The other is a future with salmon farming and a higher level of employment and income in the fisheries sector as well as the state as a whole.²⁷²

Salmon farming's conflicts with other coastal users should be addressed during the permitting process. The balance between regionwide consistency and the prerogatives of local governments should be struck according to the traditional role and capability of each. Although decisions can be made on a case-by-case method, predictability will be enhanced if governments

263. Telephone communications with J. Madden, Alaska Dep't of Fish and Game and R. Palmer, Alaska Dep't of Natural Resources, Juneau, Ak. (Feb. 3, 1988).

264. Telephone communication with J. Madden, above note 263.

265. Pierce, above note 163, at 56.

266. Weston Report, above note 62.

267. See above note 46 and accompanying text.

268. See above notes 65-82 and accompanying text.

269. See above notes 83-99 and accompanying text.

270. See above notes 168-70 and accompanying text.

271. Gillespie Report, above note 31, at 35.

272. Logan & Weddleton, above note 217.

pre-plan their coastlines into appropriate activity areas based on highest use principles.

Finally, policy makers should avoid a narrow focus in this area. Decisions which appear to be limited to specific projects or particular methods may have wider and longer implications and may set precedents difficult to reverse. This is a rapidly moving, revolutionary industry: between 1975 and 1984, aquaculture's share of total world seafood production rose from 3% to 12%.²⁷³ The reality is that aquaculture will continue to grow and to grow rapidly as a world supplier of fish protein.

Pen culture doubtlessly will be an integral component of this movement. Already European researchers are developing techniques for pen-raising halibut, cod, lobster, and other species.²⁷⁴ Decisions by policy makers today will determine if and how their constituents tomorrow will participate in the forthcoming "blue revolution."

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273. Pierce, above note 163, at 72. One British Columbia researcher predicts that the commercial raising of sablefish (black cod) in seapens will begin in 2 to 5 years. W. Nagata, Pacific Biological Station, Nanaimo, B.C., quoted in 2 Alaska Mariculture Report no. 2-3 (Dec. 1987-Jan. 1988), at 2. A Canadian company is planning to commercially farm Arctic char in the mid-1990's. Alaska Mariculture Report no. 2-3 (Dec. 1987-Jan. 1988) at 7.

274. Greer, above note 154.

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